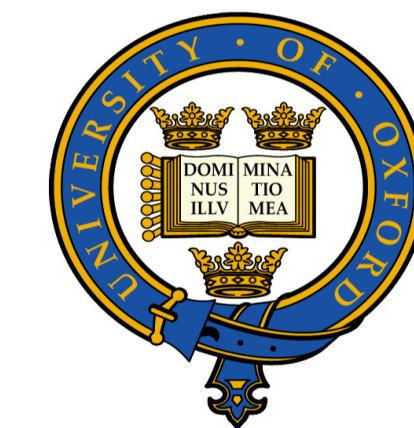




First Measurement of the W Boson Mass with CDF in Run II

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CDF Collaboration



Motivation:

W mass measurement points us to the source of mass

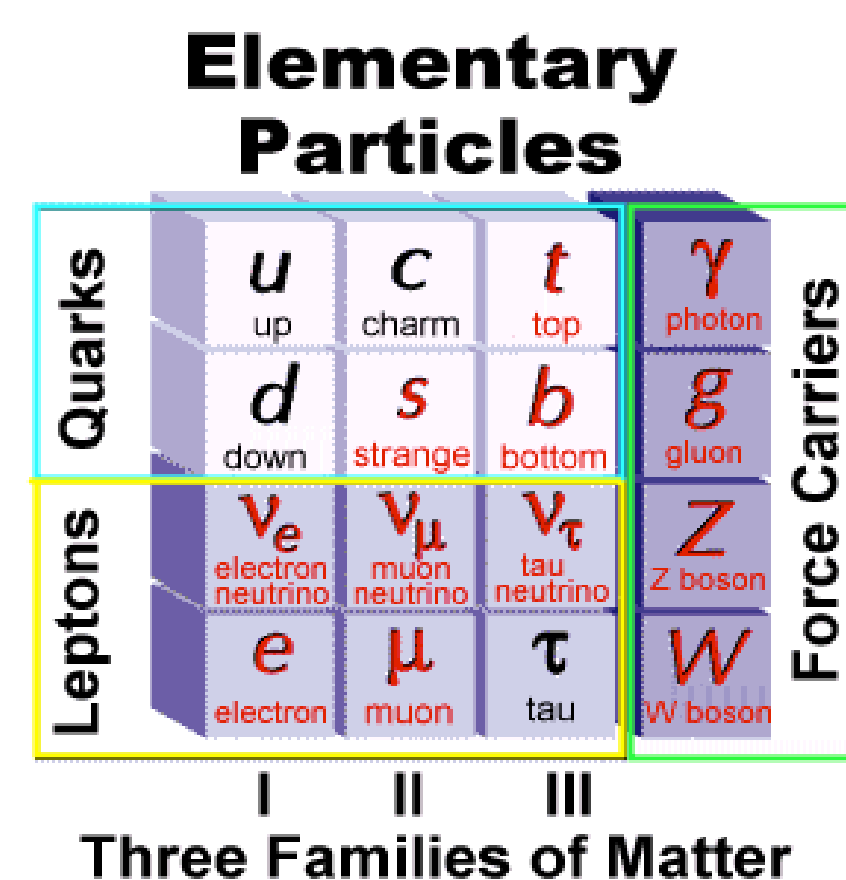
Fundamental particles of nature:

Structure due to particle mass

What is the source of mass?

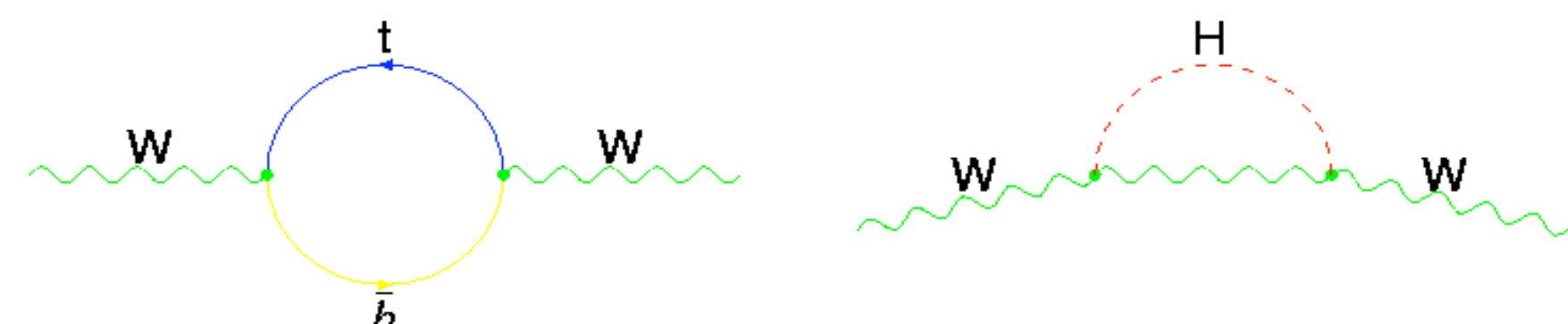
Hypothesis:

Particle mass results from interactions with the 'Higgs' energy that pervades the universe.



Requires the existence of the Higgs boson

The Higgs boson and top quark contribute radiative corrections to the W boson mass.



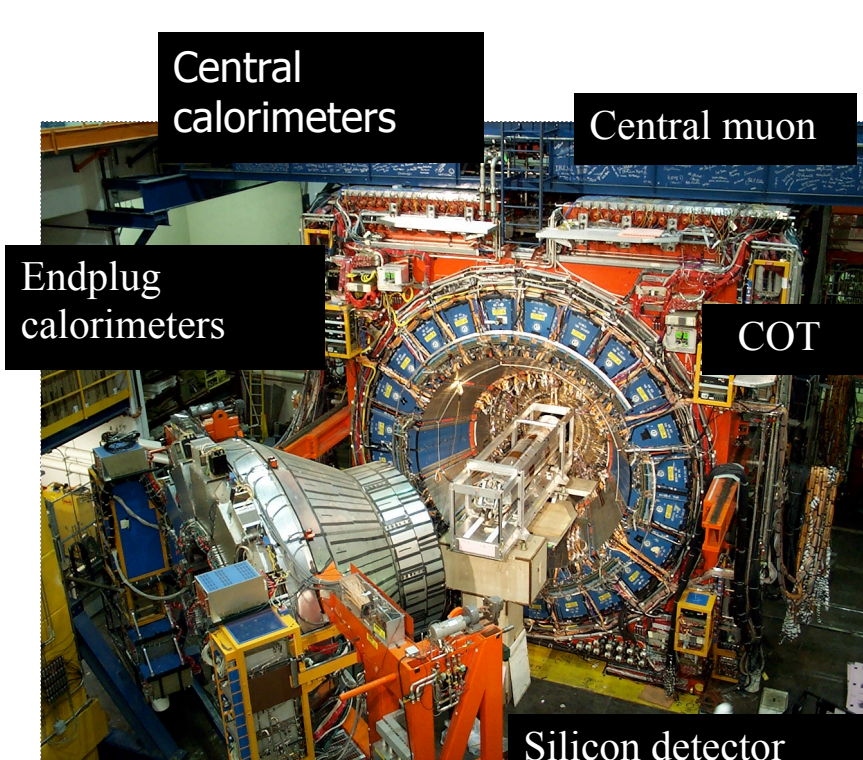
Knowledge of W boson mass predicts mass of Higgs boson

CDF at the Tevatron:

The Tevatron

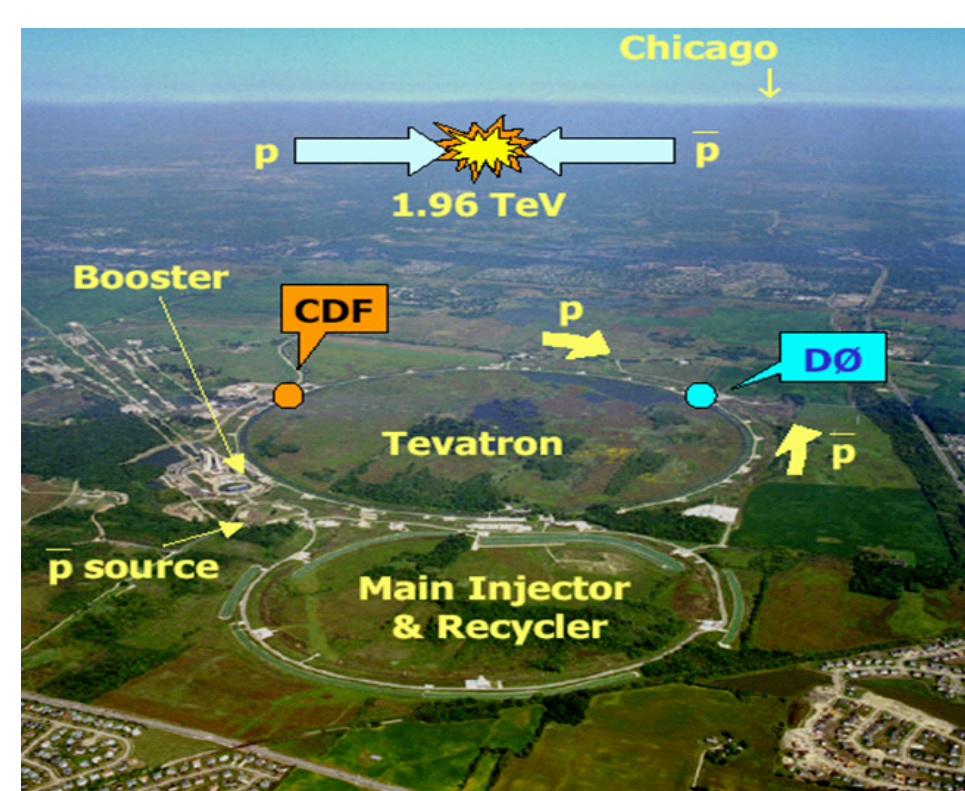
proton-antiproton collider 1.96 TeV

Highest energy collider in the world



CDF

Multipurpose detector: high resolution charged particle tracking, electromagnetic and hadronic calorimeters, and muon detectors.



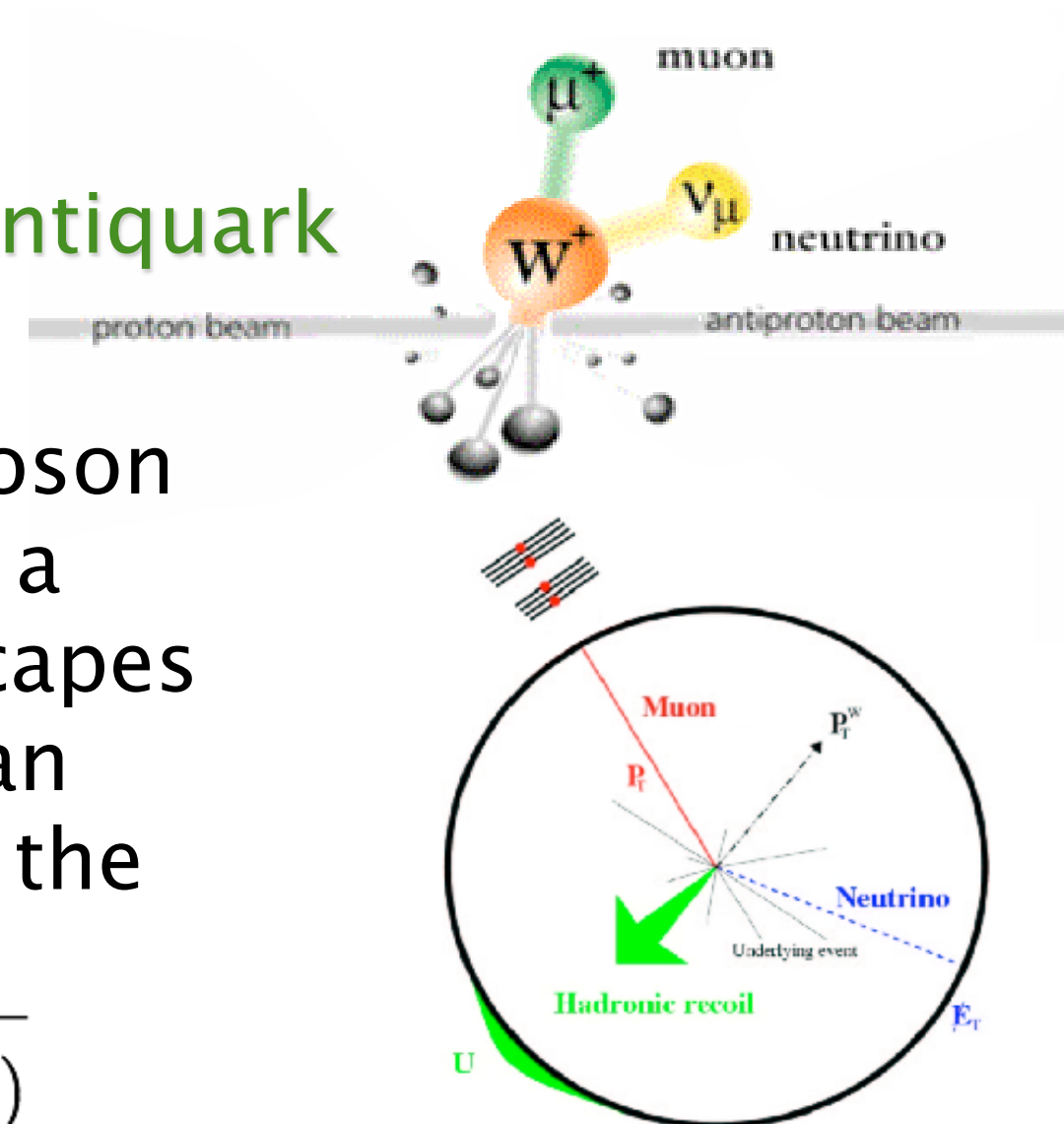
Measurement:

W bosons produced by quark-antiquark annihilation

We study events where the W boson decays to a charged lepton and a neutrino. Since the neutrino escapes detection, we cannot calculate an invariant mass. Instead, we use the transverse mass:

$$m_T = \sqrt{2E_T^\ell E_T^\nu (1 - \cos \Delta\phi_{\ell\nu})}$$

Measurement complicated by radiation of additional particles

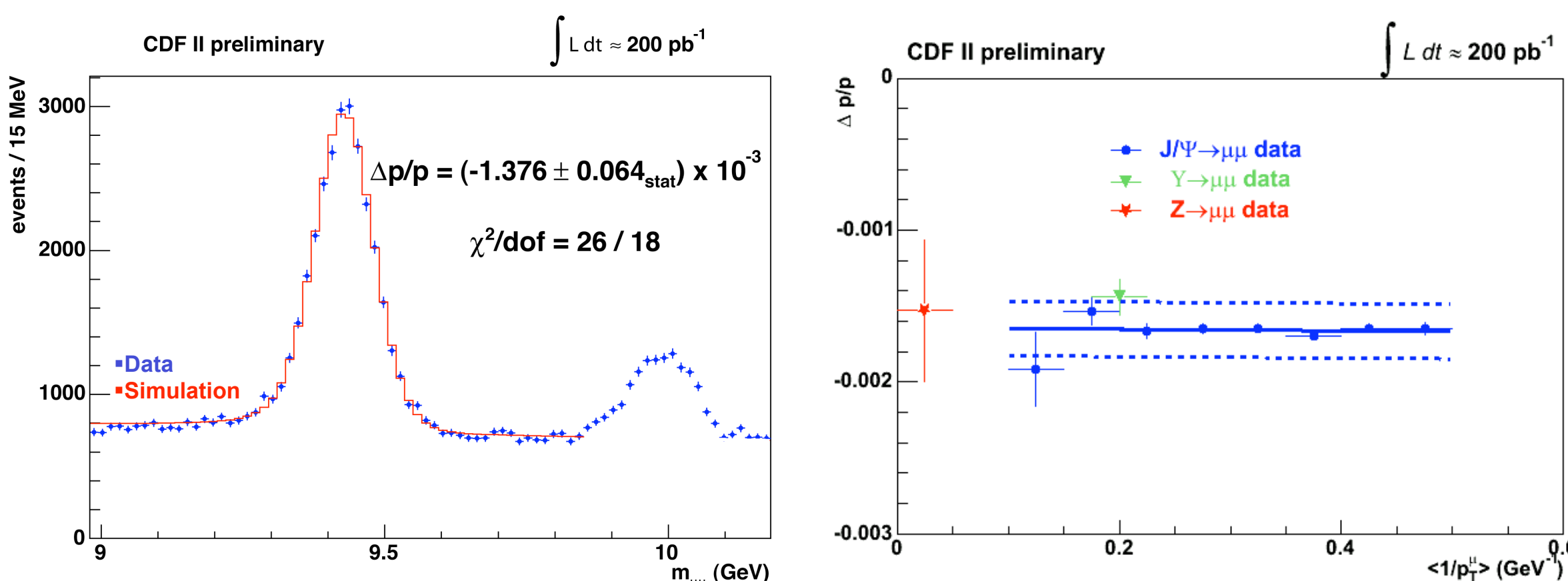


Detector Calibration:

Strategy: Calibrate using particles with well-known masses

Momentum scale

The momentum scale of particles as measured using tracks is calibrated using well-known quarkonia states, the $J/\psi \rightarrow \mu\mu$ and $\Upsilon(1S) \rightarrow \mu\mu$. An additional calibration is also obtained using $Z \rightarrow \mu\mu$ boson decays.



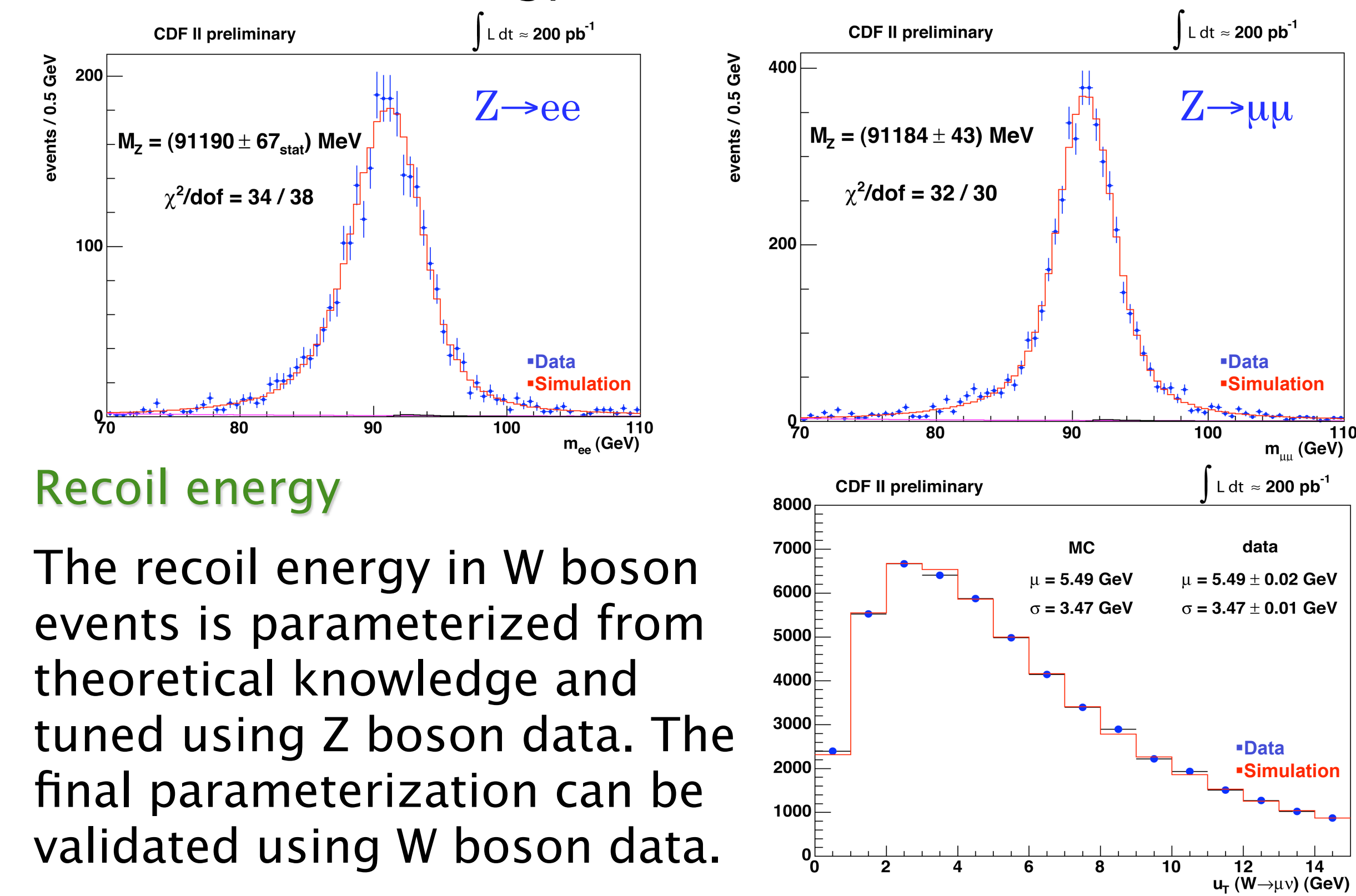
Detector Calibration and Recoil Model:

Energy scale

The calorimeter energy scale is calibrated using a fit of E/p of electrons from W boson decays. The Z boson mass is also used as an additional calibration.

Z bosons

Events with Z bosons provide decays of an object similar in mass to the W boson decaying to a fully reconstructible final state. Z boson decays are used to calibrate recoil energy against the W as well as to provide an additional momentum and energy scale calibration.

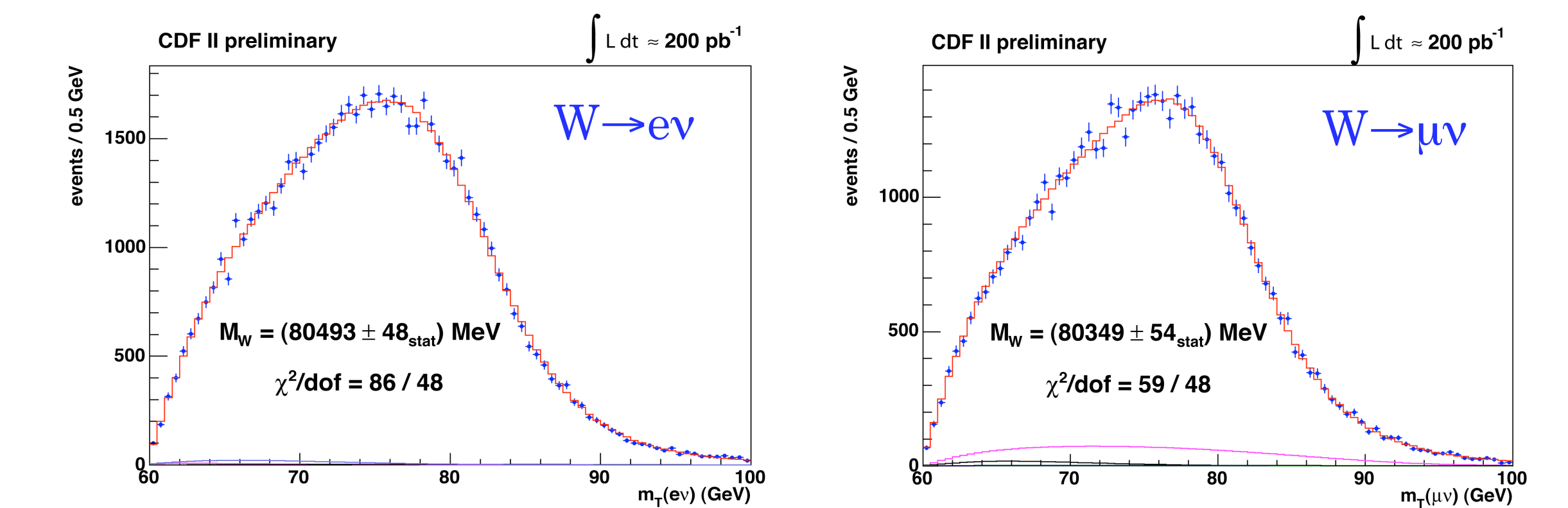


Recoil energy

The recoil energy in W boson events is parameterized from theoretical knowledge and tuned using Z boson data. The final parameterization can be validated using W boson data.

Results:

World's single most precise W boson mass measurement

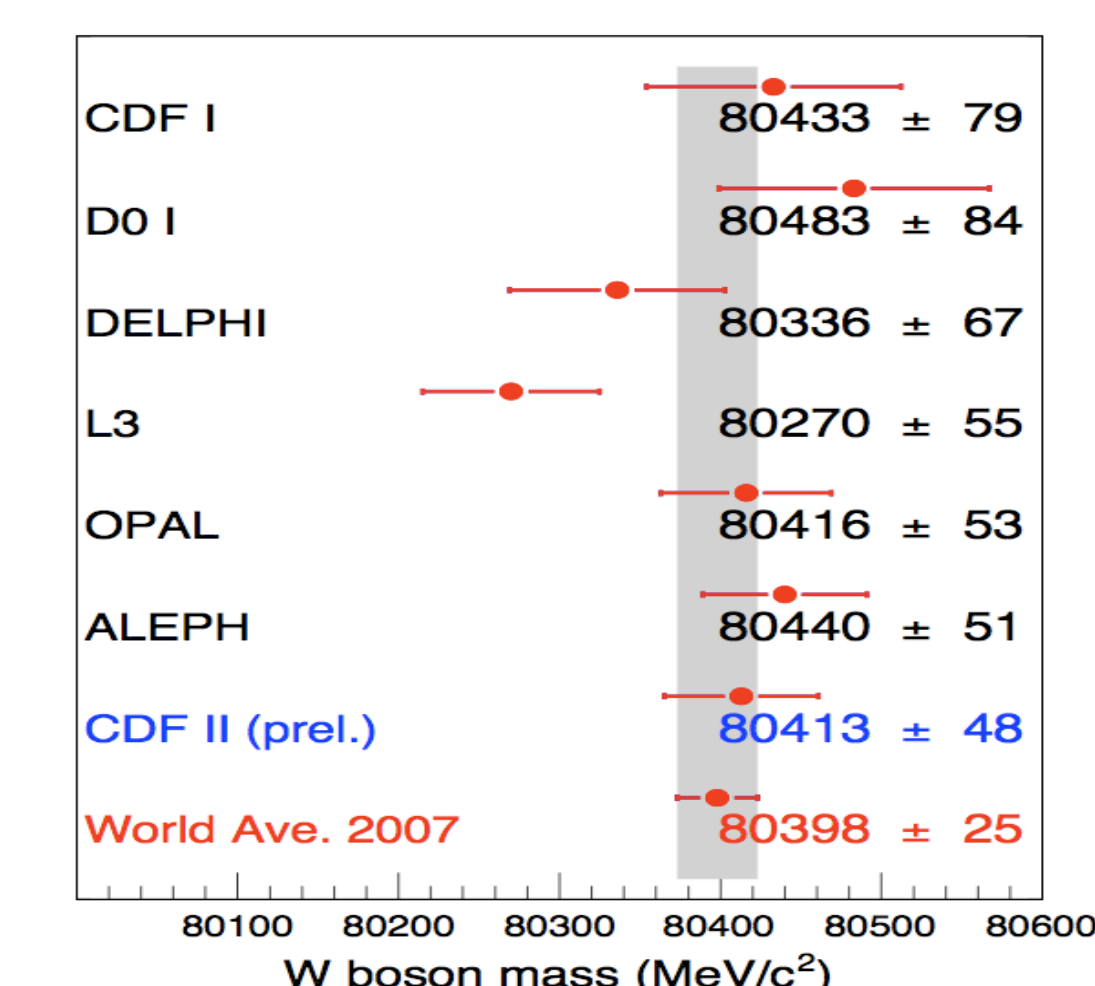


Combined fit from electron and muon decay channel yields:

$$m_W = 80413 \pm 48 \text{ MeV}/c^2$$

Uncertainties

CDF II preliminary	L = 200 pb ⁻¹		
m _T Uncertainty [MeV]	Electrons	Muons	Common
Lepton Scale	30	17	17
Lepton Resolution	9	3	0
Recoil Scale	9	9	9
Recoil Resolution	7	7	7
u _T Efficiency	3	1	0
Lepton Removal	8	5	5
Backgrounds	8	9	0
p _T (W)	3	3	3
PDF	11	11	11
QED	11	12	11
Total Systematic	39	27	26
Statistical	48	54	0
Total	62	60	26



Impact

Higgs boson mass prediction:

$m_H < 144 \text{ GeV}/c^2$ with 95% CL

Outlook

